SHORTER ARTICLES AND DISCUSSION

DOES EVOLUTION OCCUR EXCLUSIVELY BY LOSS OF GENETIC FACTORS?

In an extremely interesting article, Professor Duerden[1] has recently discussed certain aspects of evolution in the light of observations on ostrich farming. He shows that as regards most characters the germ plasm of the ostrich is remarkably stable and yet that quantitative variation as regards wing and toe characters is occurring and is being utilized, in particular for a gradual amelioration of the valued plume characters. He believes that the quantitative variation in question has a factorial genetic basis, a view which I see no reason to question. He holds that repeated selection may probably extend the existing range of variation *downward,* but not *upward.* In this last conclusion I can not concur. It rests, I believe, on too close adherence to the "presence-absence hypothesis." It assumes that minus variation occurs only by loss of factors and further that factors once lost can not be recovered. I do not think that either of these assumptions will bear critical examination. Morgan has recorded, in *Drosophila,* the occurrence of a reversed mutation by which colored eyes were recovered in a white-eyed race, and on this ground has questioned the validity of the entire presence-absence hypothesis. I have found that in the piebald patterns of rats and rabbits steady progress may be made by repeated selection in changing the racial average *either* in a plus or in a minus direction. Genetic changes affecting the extent of the pigmented areas are clearly of frequent occurrence in such cases, precisely as they are in the case of number of remiges in the ostrich wing, but there is no indication that the changes are exclusively in a minus direction, as Duerden assumes them to be in the ostrich. He has observed variation in the number of plumes on the ostrich wing ranging from 33 to 42. He assumes that the variation can probably be carried below 33 by selection, through cumulation of loss variations by dropping out of factors, but that variation in the opposite direction is not to be expected because 42 is the present maximum and factors for a higher number having once been lost can not be recovered. Of course, the thing to do in order to test the validity of this view is to give it an experimental trial,

[1] Duerden, J. E., "The Germ Plasm of the Ostrich," Amer. Nat., 53, p. 312.

and this, no doubt, Duerden is already doing. If the 42-plumed cock has descendants with a higher plume number than 42, the theory will have been disproved, which would undoubtly be highly pleasing to Duerden because it would give him a more hopeful basis for economic work. Now my own experimental work with loss-variations leads me strongly to hold the more hopeful view, that genetic changes are plus as well as minus, even in the case of structures which are in course of phylogenetic degeneration.

The degenerating lateral digits of the guinea-pig's foot[2] present a case parallel with those of the degenerating wing and the degenerating fourth toe of the ostrich. The guinea-pig, like all wild species of the genus, *Cavia,* has lost altogether the first of the five typical digits, and has lost the fifth digit from its hind foot, but not from the front foot. Some years ago I discovered a guinea-pig which had an imperfectly developed fifth digit on one hind foot. Neither of its parents had a fifth digit on either hind foot. This fact alone shows the possibility of *plus fluctuation* in a degenerate organ. The polydactylous individual, a male, was mated both with related and with unrelated females. By the former, he had 13 polydactylous and 32 normal individuals; by the latter he had 2 polydactylous and 30 normal individuals. This result showed that normal females related to the polydactyl male, even though themselves normal, transmitted a factor or factors favorable to the production of the fifth toe, since more of their offspring were polydactyl than of the offspring of ordinary females, when both sorts were mated to the same polydactyl male. Breeding the polydactyl offspring together and continuing the race by selecting those individuals which had the best developed toes (purely somatic selection), a race was secured within four generations which produced regularly 90 to 100 per cent. of polydactylous young. The race was continued for several years and showed no signs during this period of returning deterioration.

In this case we have an example of plus fluctuation in a character supposed to have been completely lost from the genus, *Cavia,* yet which, having shown itself sporadically and feebly in a single individual, was recovered and fully established as a racial character by the practise of inbreeding and selection on a purely somatic basis.

The first digit has, so far as I know, never been observed to

[2] Castle, W. E., "The Origin of a Polydactylous Race of Guinea-pigs," Publication No. 49, Carnegie Inst., Washington, 1906.

occur in the genus, *Cavia,* except in the case of a single individual born in one of our experiments. As this individual was still-born we had no chance to experiment further in the case, but the occurrence shows that degenerating characters are not of necessity lost for all time when they have ceased to have somatic expression in the race. I am therefore hopeful that Duerden will live to see not only other 42-plumed ostriches but also those which are 45-plumed or possibly even better, if selection for high number of plumes and inbreeding are persistently practised.

One point is worth noticing, which Duerden does not especially emphasize, though it is highly suggestive. He notes the advanced state of degeneration of the ostrich foot (presumably through irrecoverable loss of factors) as seen in the complete disappearance of digits 1, 2 and 5, and the greatly reduced size of digit 4, which leaves the ostrich with practically a single functional toe (digit 3), this being among birds an unparalleled amount of digital reduction. He concludes "Should the loss of plumage continue to a much further degree and marked degenerative changes be set up in the big middle toe, natural selection may then be expected to bring about extinction." This, it seems to me, is a needlessly gloomy view of the case. The fact that the middle toe is "big" contradicts the idea that it will soon degenerate as the other digits have done. If evolution occurred only by loss and never by gain, the middle toe could never have grown "big." But in reality it has probably *grown* as the other digits have disappeared. If so, factors must have been *added* to the genetic complex, or plus factorial changes must have occurred by some other means. Reduction in number of digits does not necessarily mean degeneration. Note the parallel evolution of the horse. Does any one consider it degenerate? Yet in the horse digital reduction has gone even farther than in the ostrich and for a like reason, increasing perfection of a cursorial type, for which one *good* toe is better than three or five ordinary toes. Increase in body size has occurred in both horse and ostrich concurrently with digital reduction. It too has doubtless improved the cursorial type, increasing its swiftness. Thus in the horse and in the ostrich we have the culmination of cursorial types among mammals and birds respectively. Each is highly specialized, but not on that account degenerate or verging on extinction. Extinction will come for each when man says the word but not sooner, so far as we can foresee. Great specialization or great phylogenetic age does not of necessity mean early extinction, if we may judge by

the geological history of brachiopods, echinoderms and mollusks. If a suitable environment continues, the specialized organism may continue indefinitely. The idea that genetic variation occurs only in one direction and is irreversible is widespread, but needs substantiation before we accept it into a category of fixed ideas. The world indeed may wait long to see again a four-toed horse, but the reason probably is that we already have a *better* type in the one-toed horse, which replaced the former because it *was* better, not because it was degenerate. If selection, natural or artificial, saw at the present time a distinct advantage in a polydactylous horse, it is quite possible that the type might once again be produced. The animal breeder would ask only such a start as was seen in Cæsar's three-toed steed, to produce a race of polydactyl horses.

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ANOMALOUS RATIOS IN A FAMILY OF YELLOW MICE SUGGESTING LINKAGE BETWEEN THE GENES FOR YELLOW AND FOR BLACK

DURING the course of an experiment involving the breeding of yellow and non-yellow varieties of mice certain anomalous ratios were produced by a family of yellow mice. Since an explanation of these facts brings out considerations regarding yellows which have not been treated in the literature of the subject, it seems well to put the case on record.

The peculiar family originated in a cross of black-and-tan (a very dark form of yellow) with brown. F_1 consisted of blacks and yellows. The blacks when tested proved to be heterozygous for brown and showed in their subsequent generations no peculiarities of inheritance. The F_1 yellows should theoretically have been heterozygous for both black and brown for,

Let YyBB = black-and-tan parent (yellow carrying black) and yybb = brown parent;

Then F_1 should consist of yellows, YybB, and blacks, yyBb.

These F_1 yellows were back-crossed to pure browns.

The progeny distribution to be expected would be as follows:

The F_1 yellow parent, YybB, would form gametes, YB, Yb, yB and yb.

The brown parent, yybb, would form only one type of gamete, *viz.*, yb. The expected zygotic combinations would be

The yellow young obtained from this back-cross should be of two genotypes, YyBb (carrying both black and brown) and